BUILDING ENERGY SYSTEMS AND AUDITING

Dr. Shankar Pratim Bhattacharya

Department of Architecture and Regional Planning

IIT Kharagpur

Week - 05

Lecture - 23

Lecture 23 : Computation of Residential Envelope Transmittance Value

Welcome to the NPTEL course on Building Energy Systems and Auditing. In module number 5, lecture number 23 will be discussed now. In lecture 23, we will discuss the envelope transmission value, which we have already discussed in lecture number 22, but in this particular lecture, we will see some of the analysis of RETRIB and how it will be applied in apartment buildings. So, those we will see.

So, we will start with a small problem. So, this is the 2 layout, 2 layout in the sense that there are 2 different sizes of the apartment. I have drawn only the perimeter wall. Internal walls will not participate in the RETV, so that is immaterial. So, the perimeter wall has been shown in these two figures.

The left-hand side figure envelope is actually adopted for unit A and unit B. And, the right-hand side layout, the perimeter layout, is applied for unit C and unit D. So, units A, B, C, and D are placed on a particular floor in an apartment building, and centrally there is a circulation area. Again, the exposed wall in the circulation area will not participate in the RETB calculation. So, the envelope area which is exposed to the outside, those areas of A, B, C, and D will have their role to play. So, in the corner-most figure on the right-hand side, I have shown the layout positions.

So, the smaller apartment units A and B are in the northern direction, and the larger apartment units C and D are in the southern direction. And I am assuming that the height of each floor will be 3.5 meters. So, even though it is a G+5 apartment, only a part of one floor can be calculated for this purpose because, finally, it will be repeated for all five floors or so. So, we will see that these particular apartments have two types of windows, W1 and W2. The dimensions are in the next slide, and also one glazing, G, which is mentioned here as G. All the dimensions mentioned here are in meters. So, in the next

slide, or maybe in the same slide, we have seen the table, and this table shows the width and height of the windows.

So, and also the projections. So, window 1 and window 2 have the same height of 1.2 meters, but they have different widths. 1.5 meters for window 1 and 2 meters for window 2. Whereas, the glazing has a greater depth, that is, 2 meters in depth or height, and it has a width of 2.5 meters. It does not have any projection. The wall thickness is 250 mm, and it has a brick wall with a U-value of 2.3 W/m² °C.

The windows are of 6 mm double-glazed windows (DGW), and the U-values are 3.1, and the SAGC is 0.8. Those windows are your W1 and W2, and the glazing is of 6 mm single-glazed windows with a slightly higher U-value of 5.3 and a slightly lower SAGC, of course, it is 0.6. So, based on this particular data, we should see what the RETV value is and whether the value complies with the climate of Thiruvananthapuram, which is our warm and humid climate. So, we will see that one.

So, now first of all what we have to do is that we have to see our, we have to collect or we have to note down the factors of orientation. So, in the factors of orientation, it has to be taken for the warm and humid climate because it is in Thiruvananthapuram, which is a warm and humid climate. So, A, B, and C values are taken as 5.15, 1.31, and 65.21. Now, the orientation factor, see in my proposed layout, the orientations of all the floors are exactly in the north, east, south, and west directions. So, I will have to take the orientation factor from the second list because the latitude of Tiruganandapuram is less than 23.5.

5° north and all the only the 4 values out of the 8, the north, east, south, and west, the orientation factor, the omega factors are noted down as 0.659, 1.155. For south, it is 0.966, and for the west, it is again 1.156. So, these values will be taken to our main frame of formulas which we already saw in lecture 22. Next, my job is to find out and calculate the area, the envelope area, and now you see. From the envelope point of view, let us first find out the areas of the north and south.

So, north, if you see the north, in the north we have the A and B which come from this particular unit plan. So, it is a mirror image. So, I have written down the total wall area or the length of the wall as 6 plus 4 plus 6 plus 4, that means this is your 6. is your 4. So, this is your 6, and this is your 4, and again it will be a mirror image.

So, this will be your 4, and this will be your 6. So, 6 plus 4, and 6 plus 4, plus there are 2 meters. 2 meters, which are actually this is 2 meters, and this is 2 meters, comes from this is 2 meters, and the mirror image of that one is 2 meters. So, this 2 will also come because it is also facing north, right? So, I have multiplied that by 3.5 meters because 3.5 meters is my h. So, the total 84m² is my total north facet area.

So, in gist, what I did is I took the whole length of the north-faceted wall, 6 plus 4, 6 plus 4, and again there are 2 meters, and multiplied that with the floor height h, which is 3.5, that gives me 84. So, that will actually come down to be 84m². So, now we will see some deductions because we have some kind of windows. So, how many windows are there in the north facade? Because there are 2 W1. So, this is for your W1, and this is for your W2, and this is the glazing area; there are 2 glazing areas.

So, W1 and W2 are there, the dimensions. So, W1, 2, how? Because in this particular A, there will be a W1, and there will be a W2, and there will be a glazing, and here will be a glazing, there will be a W2, and there will be a W1. So, there are 2 W1, 2 W2, and 2 glazing. So, by virtue of that, I have calculated the areas of the window and the areas of the glazing. So, finally, I found out the total envelope area minus the window and the glazing area.

So, 65.6m² is my solid brickwork, 8.4m² is the area of windows, and 10m² is the area of the glazing. Similarly, I will calculate for the east and west. So, for east and west, if you see, these are the two east and west sides. So, if I say this one, this one has to be your 6 meters, this has to be your 4 meters, and then next C and D are from the second plan. So, this is your 5 meters and this is your 7 meters.

So, it is 6 plus 4, 5 plus 7, and there are again 2 meters. So, this is your 2 meters and this is your 2 meters. So, that is also facing east, and I have multiplied it by 3.5 meters. So, that gives me 91m² as the envelope area, the facade envelope area for the east and west, and please remember this is a mirror image. So, as it is a mirror image, the 91 will remain for the east also.

So, in this, if I now see how much is the reduction for the windows and the glazing. So, from this particular key plan. So, we have 1 W1 over here and 1 W2 over here, and in glazing here, there is a glazing, then there are 2 W1, W1, and W1, and there are 2 W2. So, finally, it makes me 3 W1 and 3 W2 and 1 glazing in the east and west facade, and based on that, I have calculated the area of the window as 12.6m², the area of the glazing as 5m². Now, I can find out the solid wall area as 91 minus those areas.

So, 73.4m² is the solid wall area. So, I need those specifically, the fenestration area, two different types of fenestrations because those have different materials and different projections. So, I have to segregate those fenestrations into different ways of windows and glazing. And the wall area. So, I will take that to the next slide, and I have made a chart where I have shown the area calculation.

So, those, if I again go back a bit. So, 673.4 and 65.6 are the solid wall areas. 65.6 and 73.4. Let me check once more: 65.6 and yes, and the window areas are 8.4 in the north and south, and 10 are the glazing areas. Whereas, the window areas in the east and west are 12.6, and 5m² is the area of the glazing, and the orientation factors are also mentioned in the east, west, north, and south, which I have already taken, and I have the U values and the SAGC values as well.

Next, what we will do is I will go one by one, and I want to try to make a kind of chart and calculate the whole formula, putting the right value in the right place. So, first, the first part of the equation, that part of the equation is for the solid wall. So, the first column or the second column gives me the solid wall area. The corresponding U value is 2.3; there is no change in the U value. There are orientation factors, and these 3 multiplications is basically the area of the opaque one, the U value of the opaque, and the orientation factor multiplied with each other, each line, each orientation, and then it is added up, giving me a value of 635.32, this last value. So, I got the C summation, but I have to multiply it with A, the climate factor.

Similarly, I will go to the second part of the equation, which is the first part or U-value part of the fenestration. So, now I have to write down the fenestration area, which is the, and this fenestration area is of two types. As you know, the first is I have calculated for the windows, which have 3.1 as the U-value. And those are the areas of the window: 8.4 and 12.6. Again, the same orientation factor is taken for all four sides, and it has been multiplied and added up.

So, this 132.58 is the product of the window part of the U-value part or so, but I still have left another part of the fenestration, which is the glazing. So, for that, the glazing areas 10 and 5 have been taken into the north, south, east, and west, and the U-value has changed; it has a single glazing. So, it is 5.3; the same orientation factor is kept for the calculation, and again, multiplications and adding up give me almost about 147.37 as the glazing value.

So, now I have to add these two together and then multiply by b. So, that I will do later. These two boxes give me the two separate entities of the fenestration. Because there is a change in the U-value, and next, we will see there is a change in the shading factor or so. Now, we have the Pf, the projection factor. So, in the problem statement, it is given that the windows have 450 mm projections, which is your H.

This is your h divided by the v, which is the vertical depth of the window or 1.2 meters. So, that means this is 0.375, the projection factor, and this is I have to see Table number 11, which is for latitude less than 23.5° because it is Trivandrum, Kiro Anantapuram. So, I have to go to the right line or I have to take the row which is giving me the Pf within 0.3 to 0.39. So, based on that, I have taken the ACF, which is the equivalent shading factor of north, east, south, and west.

Which is 0.86, 0.797 for east, for south it is 0.754, and for west it is 0.796 again. So, these have been taken care of. Now, this particular shading factor will be used to calculate the equivalent shading coefficient or so. So, we have done four orientations, we have the ACF which is just now we have calculated or taken from the obtained from Table number 11.

This is for the window which is having the unshaded SHGC value of 0.6 given in the problem. So, the SHGC equivalent is nothing, but if you remember, it is nothing but SHGC unshaded by ESF. So, by dividing those ESF with 0.6, I got the equivalent factors. Equivalent factors will give me the effect of the projections in that particular window, and the areas are already there, orientation factors are there. So, now I have to multiply these three quantities: area.

The equivalent SHGC, which is this, the area is this, and this is the area. This is the equivalent SHGC and the orientation factor. The products are like this, and then I added the product. So, 20.44 is for the windows. Now, if you go to the next ESF, it is 1 for the glazing. Why 1?

Because there are no projections, no horizontal shade; it is 0. So, then there is no reduction of that kind; it will be exactly 1, and the unshaded value will remain as the equivalent one. So, 0.8 will remain; the areas are 10 and 5, and the orientation factors are the same. So, again, the multiplication of those three things will give me 22.24, which is the value of the third part of my equation, or you may say the second part of the fenestration equation.

Now, what do we have? We have a single part of the first equation, the second equation, or the second part of the equation. I have two based on the U-value of the fenestration, and fenestrations are of two types: one is a window, and one is glazing. And also, the third part of the equation gives me two values: 20.44 and 22.24. These are the glazing and window values from the SHGC point of view. So, these two are those calculations.

So, now, I have made the total I have added up. So, this, if you remember, the 60,653.32 is this value. And 217,9.95, this is there are two such values if I go back. So, it is actually the sum of 132.58 and 147.637. So, these two added together give me

give me 279.95, whereas, the third one is the third part of the equation. So, this part of the equation also comes from the addition of 20.44 and 22.24 that gives me 42.69. And, the a, b, c values are respective that the row-wise it has been mentioned and that is multiplied to each other and added up to each other and the residential transmission values are calculated based on how this. So, these 3 are added. 3s are added.

So, I can write plus, I can write plus, and this is equal to equal to this is this. Now, how did I get 18.35? 18.35 is this 6422 or this big third bracket value and this Re3b will be now RETV will be now this 6422.27 divided by the envelope area. The envelope area is 350.

It includes all the areas: the wall area, the window area, fenestration areas, and all, and that gives 18 points, which is much higher: 35W/m², if the unit isW/m². So, I must write hereW/m², which is very, very high, which is higher than 15/m², which is permissible. So, this design is not good; this design is not good. You have to reduce this value to 15 or less than 15. Not good in the sense from the envelope heat gain point of view in the warm and humid climate.

So, how can I decrease this from 18 to 15 or a little less than 15? I cannot change the areas. So, I have to go for some improved version of the material. So, I have to insulate the wall, or maybe I can go with some more chhajja to get benefit from the ACF, or maybe I can use some other type of glazing material which will give me less amount of U value or less amount of ACGC value. So, as simple as that.

So, there may be one question: why have I taken this as a G + 5 building, but why have I taken only one floor, 3.5 meters, in my calculation? Because whenever I go up another floor, the same pattern will be replicated, and the same areas will be increased, and the same proportion of the areas of the wall, the windows, the fenestrations, and the glazings

will be proportionally increased, and I have to divide that by the proportional increment of the area. So, if I take another floor, my total envelope area will be 350 plus 350. So, 700, and everything will be increased proportionally, and again I will come down to the same value of 8.35. So, if all the 5 floors are similar in nature from the elevation point of view or

From the envelope parameter point of view, the geometry of the envelope parameter or the material parameter from that point of view. So, it is It is good to calculate only for one floor, and that will remain as the RETV value for the whole building. So, next, I will have just a small analysis. So, we have supposed we started with this problem in the last class or the last lecture 22.

East, west 200, and the north and south in 400m² of the facet area, and if this is the window areas and the wall area like 40 and 160 for the east and west, 80 and 320 for the south and north. So, and if these are the window-to-wall ratio U-value of the wall, window, SHGC, etc., PF 0.5. So, based on that, how the change of orientation and how the change of latitude will work, let us see. So, this is the first table in the Excel sheet I have calculated based on those values.

And, these values are, if you see, for the climate zone of hot and dry, and I got the value as 16.8, 16.8 is something like this. So, it is going to have 16.8. Now, if I just change the orientation, that means, if the north is now and east is now 400, just change the orientation, south is again 200, now just change the orientation, everything remains the same. So, you see, it is going to change its value.

Now, if instead of this, 6.6 is your hot and dry, see I have highlighted this one: hot and dry and composite both are the same. So, if I go for the temperate climate, suppose I take this value. Now, if I copy this and paste it over here for the temperate climate. So, you see it is drastically reduced to 11.9. So, the material of your choice basket may not fit for the hot and dry and the composite climate, but it is always going to fit for the temperate climate.

Let us see this particular value whether it is suitable for the warm and humid climate or not. So, I have to change this particular table values, ah, the table 2 parameters, no it is not going to work because it is again, ah, exceeding 15 or so. So, by a slight amount, 1.3 amount. So, you have to redesign the result as it is redesigned because it is more than 15.

So, like that, we can do this, and suppose in this particular temperate, or if I just undo this one, if I go back to the temperate climate which is 11.9, and if I just change the orientation, then again, if I say the north is the higher length side and east and west are smaller length, and this is 400 and this is again 200. So, 11.9 will now change to 10.7. So, again, there is a further change. So, change of orientation is going to be a factor, you know, and the change of climate definitely is going to be a factor. So, this is what we have seen, this is for the hot and dry climate, long wall in the north and south.

If I go to the next calculation, maybe it will be the same. It is hot and dry with the long wall east and west; it is 18.8. So, it is always good to put the long wall in the north and south, as we understand from our climatological principles, but here it is also suggested the same. And we see how to operate this particular Excel sheet. I will send the Excel sheet to you through our forum, and you can ask for our technical teaching assistance; they will help you with that.

And these are the small tables I have placed for the change of orientation and also the change of the latitude. So, for hot and dry, if you see the first two lines, the change of latitude does not make much difference; warm humid also does not make any changes, and even the temperate climate does not make any big change. But there is a change in between the hot and dry, which is almost like 16 and 18.8, drastically coming down to 14.6 and 16.3, and then further going down to almost about 10 and 11 or 12 kinds of a thing. So, that is the much more effect in the change of climate and also the long wall, whether it is in the north-south direction or the east-west direction.

Around 1 to 1.5 additive value changes are there. So, we have witnessed that this has been calculated based on the data we started with, that 400 and 200 with 20 percent of the WWR and those material properties. So, using that Excel sheet, just changing the orientations and the values of the orientation factor and other values based on your latitude positions of the location. So, this particular lecture concludes with the stepwise demonstration of RETV for an apartment building. And we see how the parameter changes with the latitude and the orientation.

Thank you very much.